Title: **The effect of satellite-rainfall error modeling on soil moisture prediction uncertainty,** *Journal of Hydrometeorology* **(American Meteorological Society)**

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Abstract:

   This study assesses the impact of satellite-rainfall error structure on soil moisture simulations with the NASA Catchment land surface model. Specifically, the study contrasts a complex satellite rainfall error model (SREM2D) to the standard rainfall error model used to generate ensembles of rainfall fields as part of the Land Data Assimilation System developed at the NASA Global Modeling and Assimilation Office (LDAS). The study is conducted in the Oklahoma region, which presents a good coverage by weather radars and in-situ meteorological and soil moisture measurement stations. We used high-resolution (25-km / 3-hourly) satellite rainfall fields derived from the NOAA CMORPH global satellite product and rain gauge-calibrated radar rainfall fields (considered as the reference rainfall). The LDAS simulations are evaluated in terms of rainfall and soil moisture error. Comparisons of rainfall ensembles generated by SREM2D and LDAS against reference rainfall show that both rainfall error models preserve the satellite rainfall error characteristics across a range of spatial scales. The error-structure in SREM2D is shown to generate rainfall replicates with higher variability that better envelope the reference rainfall than those generated by the LDAS error model. Because rain-to-soil moisture error propagation exhibits a non-linear smoothing of variability, soil moisture simulations are less sensitive to the complexity of the precipitation error modeling approach. Nonetheless, perturbing satellite rainfall fields with the more complex error model leads to improved spatial variability in the simulated soil moisture ensembles, which is expected to benefit soil moisture data assimilation.

Popular Summary:

   When it rains the soil gets wet. How wet it gets depends to a large part on how much it rains. It is difficult, however, to measure precipitation accurately at daily or hourly intervals and at the global scale. And it is even more difficult to measure the corresponding soil moisture, which is important for many applications including weather and climate forecasting, agriculture, drought, floods, landslides, and human health. A standard approach to estimating soil moisture globally is therefore to use numerical models of land surface processes (so-called land surface models) to convert the precipitation estimates into soil moisture estimates. Naturally, uncertainty in the input precipitation estimates is a major source of error in the land surface fields (such as soil moisture) obtained from such land surface models. The uncertainty in modeled soil moisture is particularly important in so-called land data assimilation systems that merge model-based information with independent satellite estimates of soil moisture to provide optimal estimates based on both sources of information.

In this context, it is important to have an appropriate model for the error structure of precipitation estimates from satellite sensors. This study assesses the impact of satellite-rainfall error structure on soil moisture simulations by contrasting a complex satellite rainfall error model (SREM2D) to the standard rainfall error model used to generate ensembles of rainfall error fields as part of the Land Data Assimilation System developed at the NASA Global Modeling and Assimilation Office (LDAS). The study is conducted in the Oklahoma region, which presents a good coverage by weather radars and in situ meteorological and soil moisture measurement stations. We used high-resolution (25-km / 3-hourly) satellite rainfall fields and rain gauge-calibrated radar rainfall fields (considered as the reference rainfall). The soil moisture simulations based on the two rainfall error models are evaluated in terms of rainfall and soil moisture error. Comparisons of rainfall ensembles generated by SREM2D and LDAS against reference rainfall show that both rainfall error models preserve the satellite rainfall error characteristics across a range of spatial scales. The error-structure in SREM2D is shown to generate rainfall replicates with higher variability that better envelope the reference rainfall than those generated by the LDAS error model. Because rain-to-soil moisture error propagation exhibits a non-linear smoothing of variability, soil moisture simulations are less sensitive to the complexity of the precipitation error modeling approach. Nonetheless, perturbing satellite rainfall fields with the more complex SREM2D error model leads to improved spatial variability in the simulated soil moisture ensembles, which is expected to benefit soil moisture data assimilation.